



EFFICIENCY

PROFITABILITY

COMPETITIVENESS

# SOLAR HEAT FOR INDUSTRY

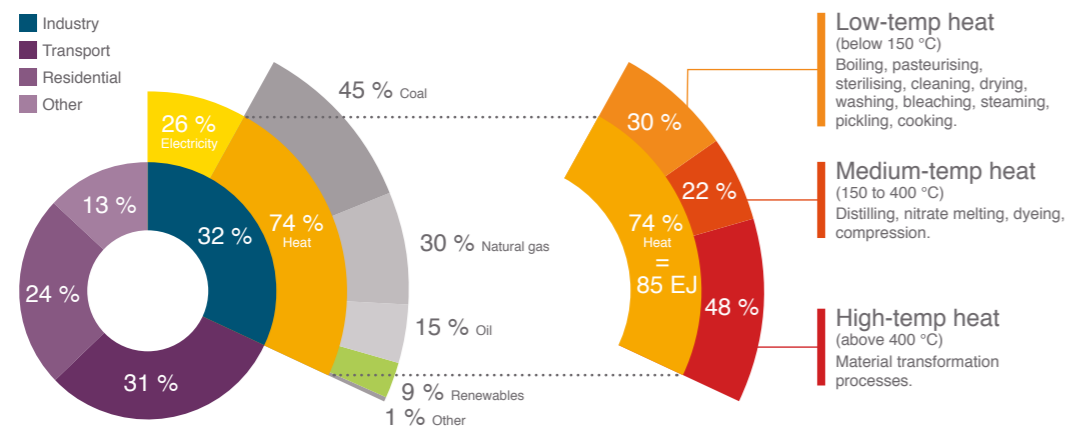


Solar  
Payback

# INDUSTRIAL SOLAR HEAT PAYS OFF

There is more final energy consumption of heat in the industrial sector than there is electricity consumed worldwide. Electricity, however, is talked about more.

## ENORMOUS GLOBAL HEAT DEMAND IN INDUSTRY



TOTAL FINAL ENERGY CONSUMPTION 2014: 360 EJ (EXAJOULE, see Glossary page 17); IEA [1]

IRENA [2]

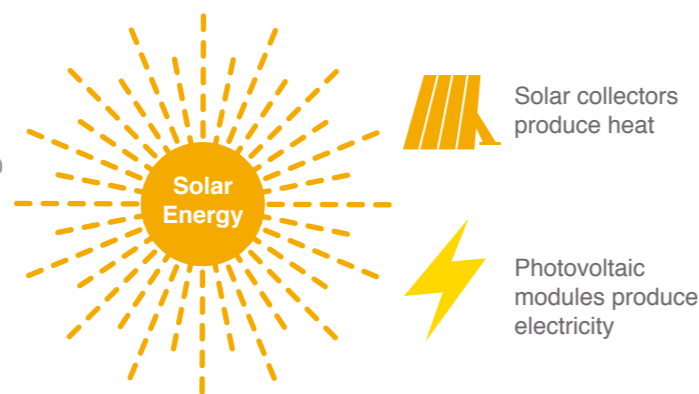
## INDUSTRIAL HEAT DEMAND ON THE RISE

**1.7 %**  
Average annual growth of industrial heat demand until 2030 [4]

**90 %**  
Met by coal, oil and gas

## POWERFUL RESOURCE

- Reliable for millions of years
- No transportation
- No taxation
- Independent of geopolitical crisis



**23.7 %**  
Renewable energy share (including hydropower) in final global **electricity** consumption across all sectors

REN21

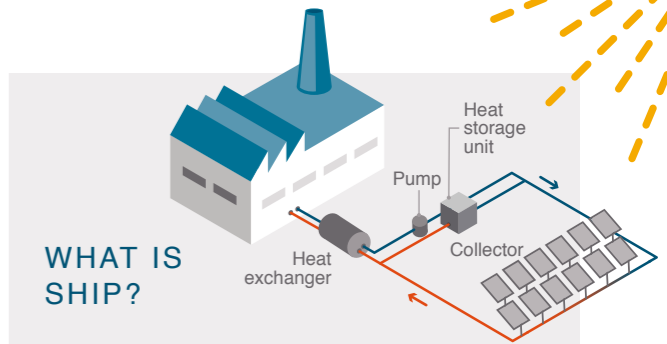
**9 %**  
Renewable energy share in final **heat** consumption of global industrial sector

**0.001 %**  
Solar share in final heat consumption of global **industrial** sector

More than **500** industrial manufacturers trust solar heat worldwide.



More than **400,000 m<sup>2</sup>** of collector and mirror area ( $\approx 280 \text{ MW}_{\text{th}}$ ) produce **Solar Heat for Industrial Processes** around the globe.

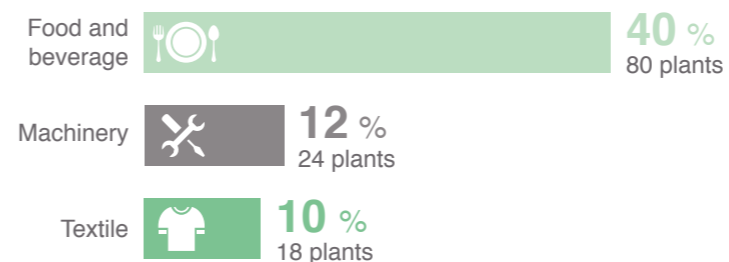


SHIP is the acronym for **Solar Heat for Industrial Processes** and describes systems which provide solar heat in a factory. A collector field heats a process fluid by means of solar radiation and a heat exchanger transfers this heat to a supply system or production process in the factory as hot water, air flow or steam. Storage units make it possible to use the generated heat at night-time.

ESTIF [4]

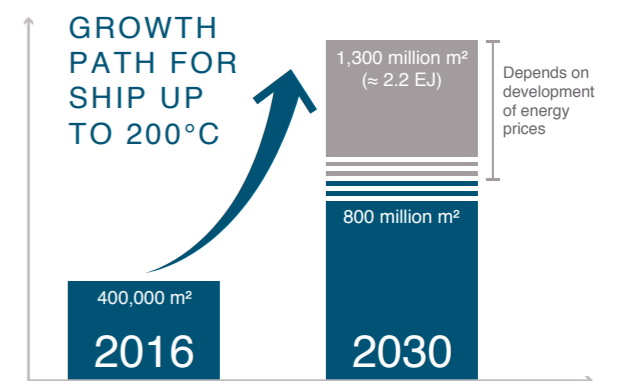
## MAJOR INDUSTRIES

Industry segments with highest number of realised SHIP plants



SHIP-PLANTS.INFO [5]

## GROWTH PATH FOR SHIP UP TO 200°C



ECONOMICALLY REALISABLE POTENTIAL GLOBALLY; IRENA [3]

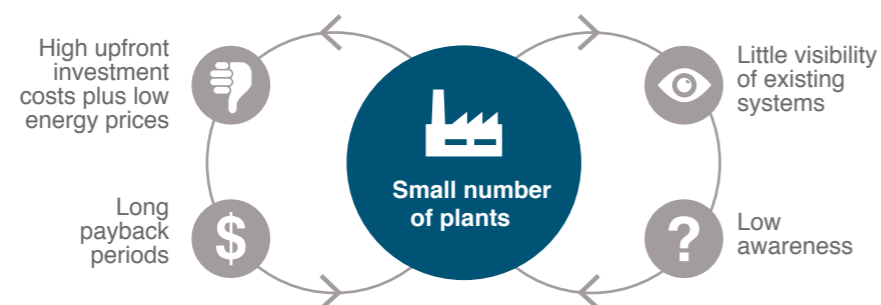
## FOUR REASONS FOR SOLAR HEAT

- Profit from the most powerful energy resource on earth
- Harvest three times more energy from the sun than with photovoltaics
- Replace imported fuels with local jobs
- Increase competitiveness of domestic manufacturing

## IEA CONFIRMS

Solar heating and cooling not on track for 2 °C scenario

## VICIOUS CIRCLE OF LOW DEPLOYMENT RATES



Three ways to break the vicious circle

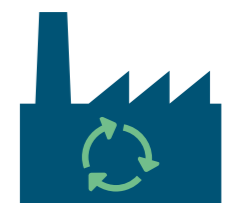
Greatly step up communication efforts to raise awareness of the technology among potential customers in industry.

70 % of turnkey SHIP suppliers (strongly) agree that SHIP has already been competitive in many markets, but is not known well enough to customers.

Support financing models to reduce risks and initial costs to small and medium industrial investors.

79 % of turnkey SHIP suppliers (strongly) agree that heat supply contracts / ESCO models are an important means of increasing deployment.

Implement measures for raising energy prices (e.g. carbon tax) or stipulating a renewable quota in certain industries.



# SATISFIED INVESTORS

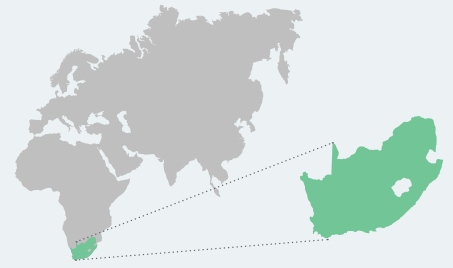
**SOUTH AFRICA**  
**Cape Brewing Company** • Brewery

Photo: CBC



**120 m<sup>2</sup>**  
 (84 kW)  
 Gross collector area  
**ZAR 1.4 million**  
 (USD 110,000)  
 Investment incl. installation

**Heating of process water**  
**70 - 90 °C**



The solar system was integrated within one day, so we succeeded to have minimum interruption of our day-to-day operation. At current rate, a realistic ROI is +/-6 years.

**Andy Kung**, Chief Operating Officer, Cape Brewing Company

Year of installation 2015	
Solar fraction	<b>29.6 %</b> of total paraffin demand
Subsidy	<b>EUR 30,000</b> from SOLTRAIN
Annual savings	<b>19,386</b> litres of paraffin
Turnkey supplier	<b>E3 Energy</b> South Africa

Photo: Bärbel Epp



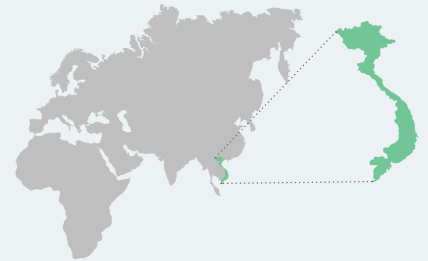
**VIETNAM**  
**ISA TanTec** • Tannery

Photo: ISA TanTec



**1,050 m<sup>2</sup>**  
 (735 kW)  
 Gross collector area  
 (Non-pressurised)  
**USD 350,000**  
 Investment incl. installation

**Retanning**  
**70 °C**



Solar heat helps us to reduce energy costs significantly and more important, it keeps them predictable and stable. In fact, it also makes us more competitive and attractive on the market, as our customers are increasingly looking for eco-friendly suppliers.

**Tom Schneider**, Co-founder, ISA TanTec

Year of installation 2010	
Solar fraction	<b>15 %</b> of total factory Approx. <b>30 %</b> of retanning process
Annual savings	<b>120,000 kg</b> compressed natural gas
Turnkey supplier	<b>Aschoff Solar</b> Germany

Photo: ISA TanTec





Process heat for  
the paint shop  
50 °C

394 m<sup>2</sup>

(276 kW)

Gross collector area

CHF 477,737

(USD 475,000)

Investment incl. installation



We want to be the most attractive provider of energy-efficient solutions for healthy and comfortable room conditions. Not only for our products and system solutions, but also for our own buildings and production plants.

**Heiner Schürch**, Project Manager, Zehnder Group International



Photo: Zehnder Group International

**SWITZERLAND**  
**Zehnder Group Produktion**  
Gränichen • Heating / Cooling /  
Ventilation Appliances



Photo: Zehnder Group International

**Year of installation 2012**

Solar fraction	<b>50 %</b> of the total heat demand in the paint shop
Subsidy	<b>CHF 164,000</b> (USD 163,000)
Annual savings	<b>16,800 kg</b> liquefied petroleum gas
Turnkey supplier	<b>Eisenmann / Ritter XL Solar</b> , Germany



Steam heating for  
milk pasteurisation,  
evaporation and  
sterilisation  
140 °C

561 m<sup>2</sup>

(393 kW)

Aperture mirror area

INR 15,682,635

(USD 942,000 )

Investment incl. installation



We strongly believe green energy to be the future of sustainable development. The concentrating solar thermal project was implemented as a pathbreaking showcase, with more to come. It delivers the projected output, and we are exploring to replicate this at several other union member's dairy plants.

**Arvindkumar Dhagat**, Senior General Manager, Amul Fed Dairy



Photo: Amul Fed Dairy

**INDIA**  
**Amul Fed Dairy • Dairy**



Photo: Amul Fed Dairy

**Year of installation 2016**

Solar fraction	<b>0.59 %</b> of total steam demand of dairy plant
Subsidy	<b>INR 3,322,944</b> (USD 46,500)
Annual savings	<b>53,000 m<sup>3</sup></b> natural gas
Turnkey supplier	<b>Thermax</b> India

**AUSTRIA**  
**Fleischwaren Berger**  
 • Meat Products

Photo: Fleischwaren Berger



**1,067 m<sup>2</sup>**  
 (747 kW)  
 Gross collector area

**EUR 735,000**  
 (USD 780,000)  
 Investment incl. installation

Preheating of feed water  
 for steam boiler  
**30 - 90 °C**  
 Hot water for cleaning  
 and drying  
**40 - 70 °C**



Year in, year out, we had thought about using solar energy for our ham production. What ultimately helped us to turn this idea into a reality was the in-depth advice and expertise of Austrian service providers. Running an environmentally friendly business is a wonderful experience.

**Rudolf Berger**, Chief Executive Officer, Fleischwaren Berger

Year of installation 2013	
Solar fraction	<b>3.1%</b> of total heat energy demand (2016)
Subsidy	<b>15 %</b> from Austrian government <b>50 %</b> from EU project INSUN
Annual savings	<b>62,500</b> litres of oil
Turnkey supplier	<b>S.O.L.I.D.</b> Austria

Photo: Fleischwaren Berger



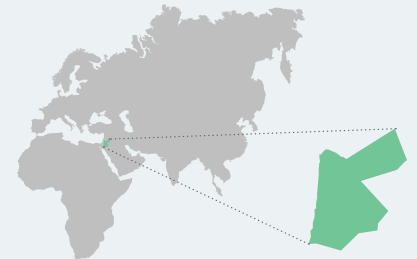
**JORDAN**  
**RAM Pharma**  
 • Pharmaceuticals producer

Photo: RAM Pharma



**396 m<sup>2</sup>**  
 (277 kW)  
 Mirror area  
 (Direct steam generation)

Steam heating,  
 (sterilisation,  
 drying, fermenting)  
**160 °C**



RAM Pharma is committed to reduce its CO<sub>2</sub> emissions. We decided to use Fresnel collector technology, as it's the best option for generating solar process steam. Our system was commissioned in March 2015 and cut diesel consumption by 42 %, exceeding expectations.

**Dr. Mahmoud Al Najami**, General Manager, RAM Pharma

Year of installation 2015	
Solar fraction	<b>30 - 40 %</b> of annual diesel demand for all processes
Turnkey supplier	<b>Industrial Solar</b> Germany

Photo: Silke Anders





Pasteurisation  
of fresh milk  
**78 °C**

**420 m<sup>2</sup>**  
(294 kW)  
Aperture mirror area  
**MXN 1,837,800**  
(USD 105,000)  
Investment incl. installation



We have greatly profited from our solar investment. It not only allows us to use the sun's energy to pasteurise 350,000 litres of milk ten hours a day, but pasteurisation has become easier to manage. The solar heat system provides much more stable temperatures than the steam boilers we use.

**Mario Tellez**, Chief Operating Officer, Lechera Guadalajara

**MEXICO**  
**Lechera Guadalajara**  
• Dairy



Photo: Inventive Power



Photo: Inventive Power

**Year of installation 2016**

Solar fraction	<b>35 %</b> of the heat demand in the pasteurisation process
Annual savings	<b>85,038 m<sup>3</sup></b> natural gas
Turnkey supplier	<b>Inventive Power</b> Mexico



Drying of precast  
reinforced  
concrete elements  
**50 - 90 °C**

**1,410 m<sup>2</sup>**  
(987 kW)  
Gross collector area  
**EUR 1 million**  
(USD 942,000)  
Investment incl. installation



We use the sun's power to dry precast concrete elements in summer and heat our facilities in winter. It is a most effective way of preparing for the challenges ahead and boosting competitiveness and productivity.

**Anton Karner**, Managing Director, Habau Group

**AUSTRIA**  
**Habau Group**  
• Construction Industry



Photo: Habau Group



Photo: Gasokol

**Year of installation 2014**

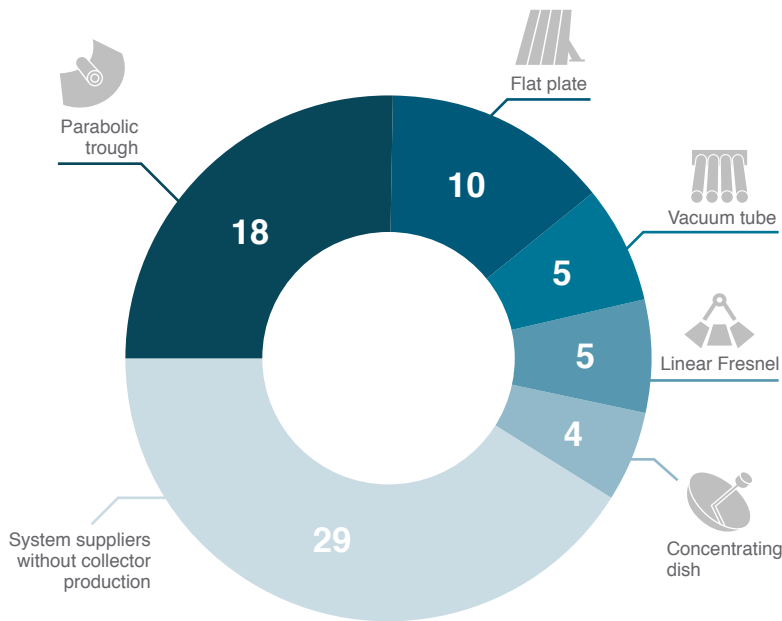
Solar fraction	<b>35 %</b> of heat demand for drying
Subsidy	<b>30 %</b> from Austrian government
Annual savings	<b>70,000 m<sup>3</sup></b> natural gas for solar process heat and space heating
Turnkey supplier	<b>Gasokol / FIN - Future is Now</b> <b>Kuster Energielösungen</b> , Austria

# SURPRISINGLY POPULAR

Solar Heat for Industrial Processes (SHIP) is still far from being a standard, but the market has already grown to a considerable size: The first **World Map of Solar Process Heat Specialists 2017** (see page 10/11) shows, all in all, **71 suppliers of turnkey SHIP systems**. The following charts show the most relevant results from the accompanying survey (see glossary, page 17).

## Parabolic trough is the most common collector type

42 turnkey SHIP suppliers depicted on the world map own collector facilities



## Turnkey suppliers based on number of reference projects

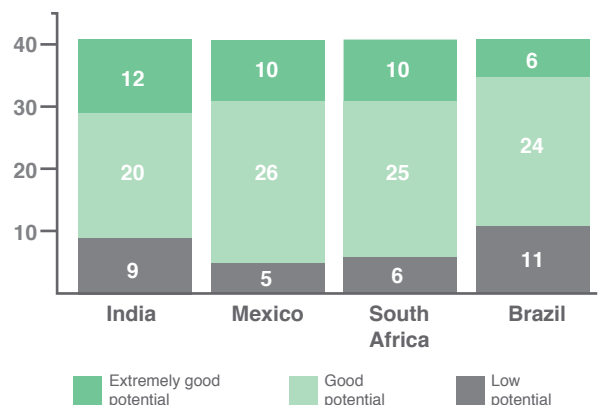
49	Sunrain Group China
35	Inventive Power Mexico
33	Modulo Solar Mexico
29	Ritter XL Solar Germany
24	Linuo Paradigma China
21	Millennium Energy Industries, Jordan
20	Vicot Solar Technology China
20	Inter Solar Systems India
18	SEA Sistemas de Ecotecnias Ambientales, Mexico
15	Sunda Solar Energy Technology, China
12	Soliterm Group Germany
12	Taylor-made Solar Solutions, India
10	Megawatt Solutions India
8	Aschoff Solar Germany
8	Industrial Solar Germany

Country	Supplier
Austria	S.O.L.I.D.
Chile	Pampa Elvira Solar
China	Sunrain Group Vicot Solar Technology Himin Solar Linuo Paradigma
Denmark	Aalborg CSP
India	Inter Solar Systems
Germany	Soliterm Group

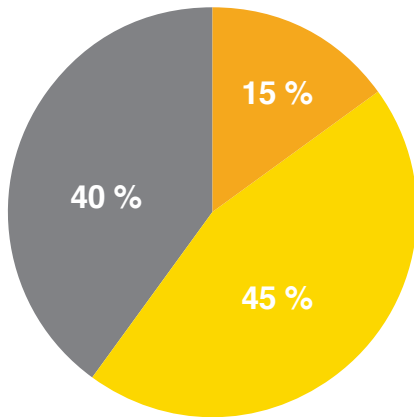
**Turnkey suppliers that sold SHIP systems with a total of more than 10,000 m<sup>2</sup>**

## High rating for Solar Payback markets

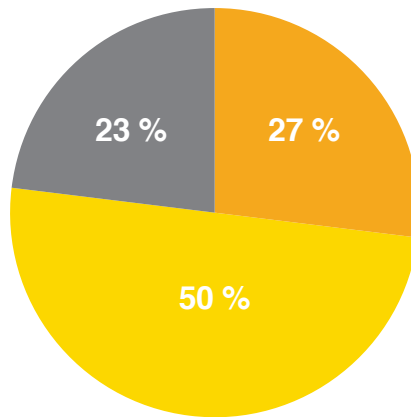
An overwhelming majority of SHIP suppliers acknowledged the (extremely) good market potential of the four Solar Payback countries.



## Were you satisfied with your business development in 2015?



All 71 turnkey suppliers



26 turnkey suppliers from the Solar Payback countries\* were more satisfied than turnkey suppliers globally



\*India, Mexico, South Africa and Brazil

## HEAT SUPPLY CONTRACTS ARE AN IMPORTANT MEANS TO INCREASE DEPLOYMENT

Most turnkey SHIP suppliers (strongly) agree with the following statements:

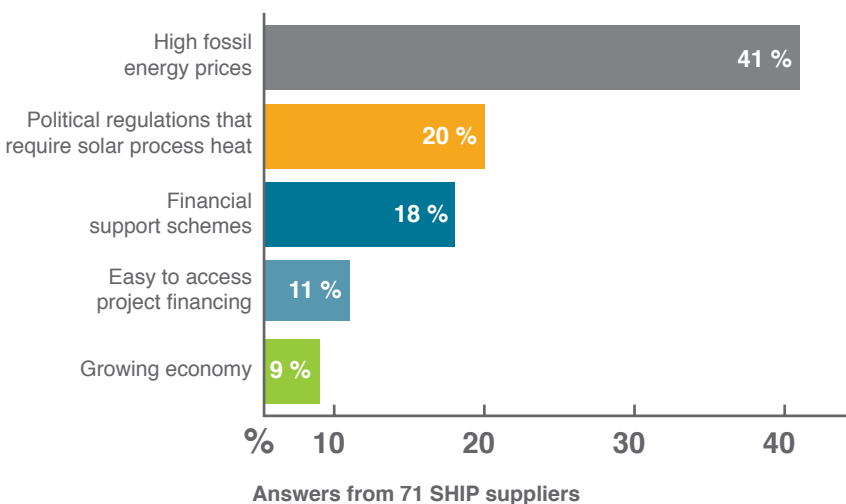
- ▶ 54 % mention difficulties with securing funds as one of the main retarding factors
- ▶ 63 % believe that huge efforts are needed to make solar process heat projects bankable
- ▶ 79 % see heat supply contracts / ESCO models as an important means to increase deployment
- ▶ Only 34 % have offered solar heat supply contracts so far

To foster the growth of the industry, ESCOs will need much more support in the form of low-interest loans and contingency or cancellation insurance.

## HIGH FOSSIL FUEL COSTS AND ENVIRONMENTAL REGULATIONS STRENGTHEN INDUSTRY

When asked about market barriers, the SHIP planners often mentioned low fossil fuel prices. Other frequently cited issues were the high cost of systems and, consequently, long payback periods. Hence, 41 % of respondents chose high energy prices as the most important factor in growing the market.

Which are the most relevant criteria for a good market development? (two answers possible)



The acute lack of awareness about how solar heat can be a reliable and economically feasible option for high-temperature supply can be addressed by pioneering efforts and showcase projects.

**Bhoovarhan Thirumala**  
CEO of Aspiration Energy, India








# 71 suppliers of turnkey solar process heat systems in 22 countries



**Publisher:** Sun & Wind Energy, [www.sunwindenergy.com](http://www.sunwindenergy.com)  
**Financial support:** Solar Payback project by the International Climate Initiative (German Federal Environment Ministry)  
**Editors:** Bärbel Epp, Eva Augsten, [www.solrico.com](http://www.solrico.com)  
**Design:** Eilers-Media, [www.eilers-media.de](http://www.eilers-media.de)  
**Date:** January 2017  
**Sources:** Data from manufacturers, November/December 2016 survey

## Legend


3 (670 m<sup>2</sup>)  
 n/a  
 Number and total area of supplier's turnkey systems  
 Companies with reference projects, but did not deliver figures  
 Companies that are listed without any references are ready to offer turnkey solar process heat systems. Still, they may have experiences with commercial solar installations, e.g., for cooling or power generation.


Several businesses also produce collectors:

-  Flat plate
-  Vacuum tube
-  Concentrating dish
-  Parabolic trough
-  Linear Fresnel

Company name\*  
 Prototype collector  
 Company offers solar heat supply contracts (ESCO)

## Examples:

**Ritter XL Solar**  Ritter XL Solar manufactures vacuum tube collectors. The company has set up 29 turnkey solar process heat installations totalling 5,165 m<sup>2</sup> of collector area.

**Chromasun**  Chromasun does not produce collectors and has not yet carried out any projects matching the definition of solar process heat below. It is ready to offer solar heat supply contracts.

**Definition:** Solar process heat plants supply heat to manufacturing companies for production processes, cleaning or sterilising. This definition does not include installations for solar cooling, electricity generation or energy use in service sector applications, e.g., for laundries and catering.

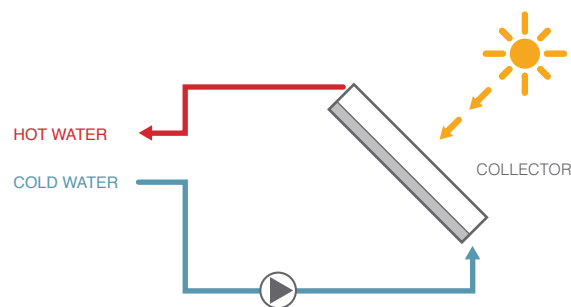


# WORLD MAP OF SOLAR PROCESS HEAT SPECIALISTS 2017

# SOLAR COLLECTORS FOR INDUSTRIAL APPLICATIONS

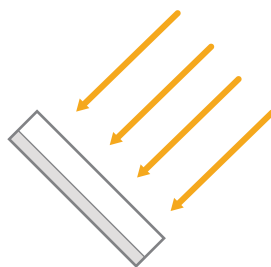
## COLLECTOR

A solar thermal collector captures solar radiation hitting a surface, the absorber, to heat a fluid in a hydraulic circuit.

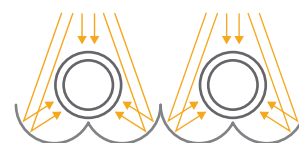


## COLLECTOR TYPES

**Stationary**  
Fixed tilt or seasonally adjusted

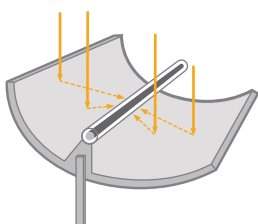


- Flat plate collector
- Vacuum tube collector

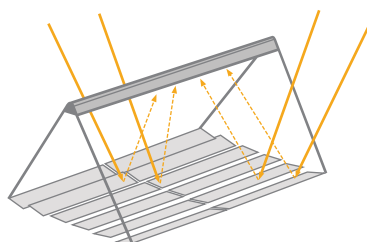


- Vacuum tube collector with compound parabolic concentrator (CPC)

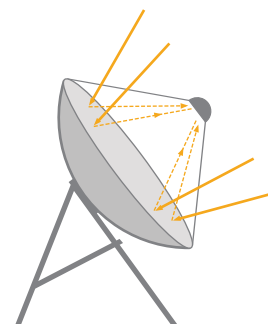
**Tracking**  
Linear or two-axis tracking



- Parabolic trough collector



- Linear Fresnel collector



- Concentrating dish collector

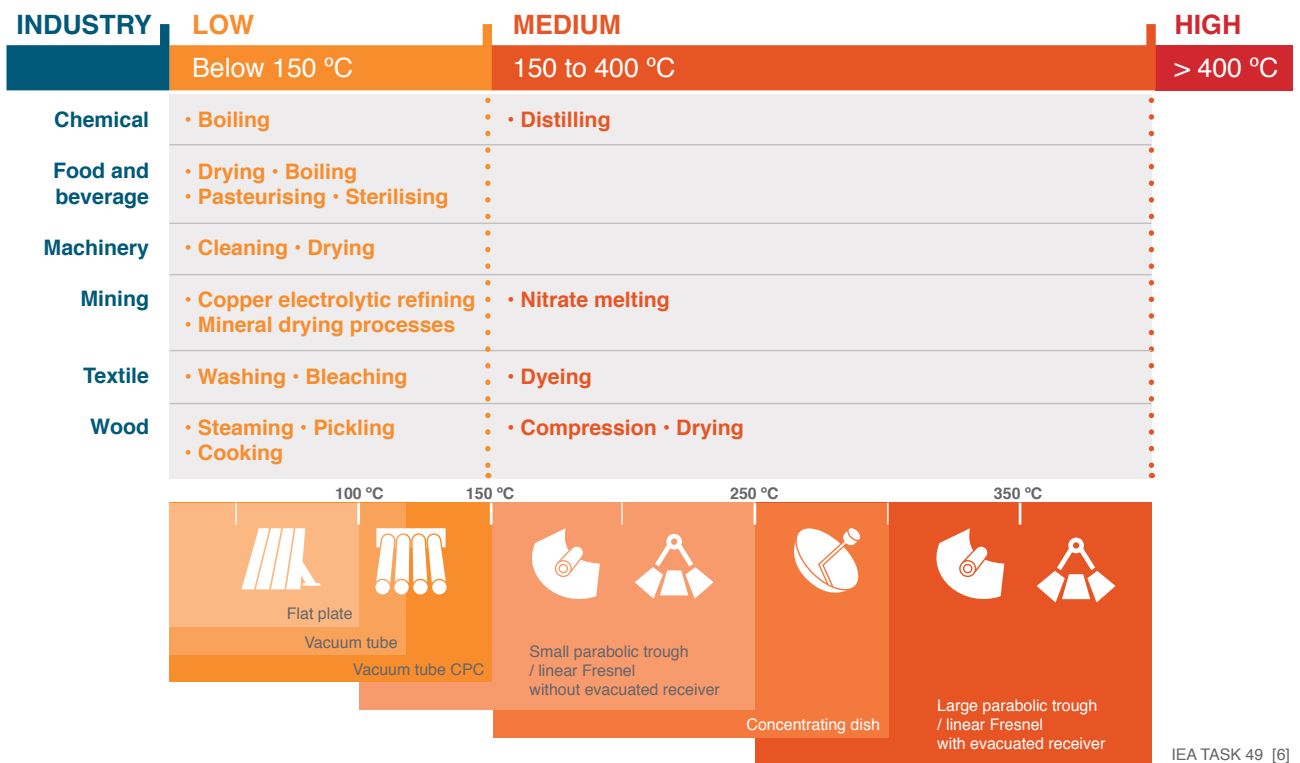
## WHAT TO CONSIDER WHEN CHOOSING A COLLECTOR TYPE

- ▶ Typical operation temperature of the collector type meets the requirements for the industrial heat (see next page)
- ▶ Design accommodates chosen heat transfer fluid
- ▶ Certified according to national or international standard, such as:
  - Solar KEYMARK (Europe)
  - Solar Rating & Certification Cooperation, SRCC (USA)
  - Bureau of Indian Standards (BIS)
  - NMX-ES-001-NORMEX (Mexico)\*
  - South African Bureau of Standards (SABS)\*
  - National Institute of Metrology, Quality and Technology, INMETRO (Brazil)\*
  - Chinese National Standard \*
- ▶ Energy output certified by accredited third party
- ▶ Enough pressure resistance
- ▶ Adequate stagnation handling and overheating prevention (see glossary, page 17)
- ▶ Suitable weight for rooftop installation or appropriate size for ground-mounting

\* These standards do not yet include concentrating collectors.

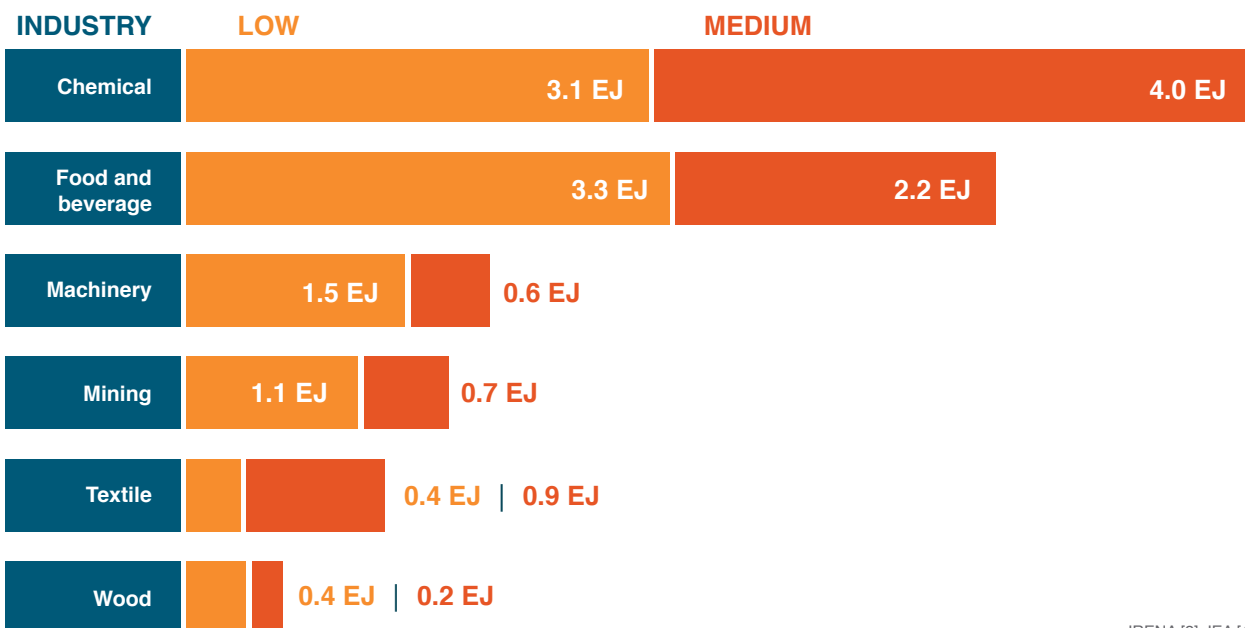
## MARKET SEGMENTS

Solar collectors supply heat at different temperatures for production processes in several industries. The chart below shows the market segments most suitable for each collector type.



## HEAT DEMAND

The total heat demand for low and medium temperature applications accounts for **44 EJ** (exajoule) globally (≈12,222 TWh). The chart below shows this heat demand in selected industries.



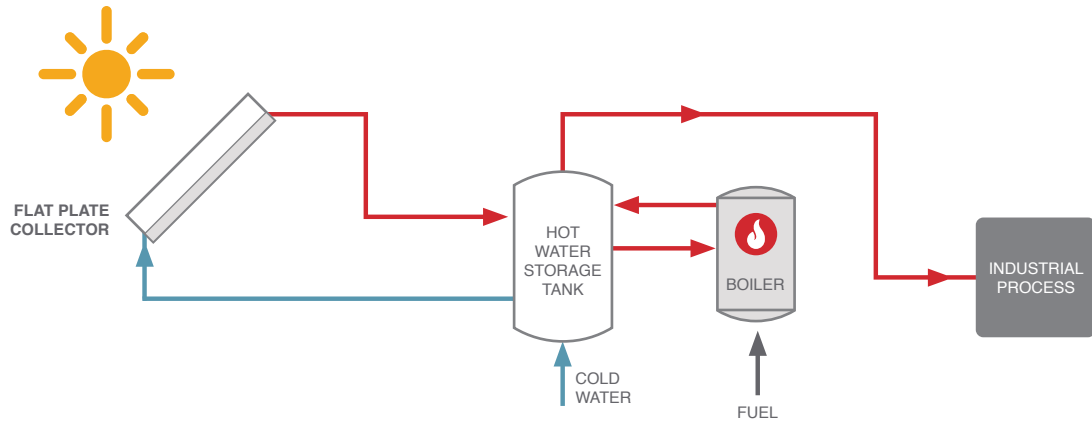
IRENA [2], IEA [1]

## SYSTEM INTEGRATION

Solar heat can be provided at different integration points. Preheating is the most common method of incorporating solar heat into the production cycle. However, it can also be used to generate steam or fed directly into the process loop.

### Preheating

Cold water is preheated in the solar field and fed into a storage tank where it is heated up by a fossil fuel boiler to the required temperature of the production process.

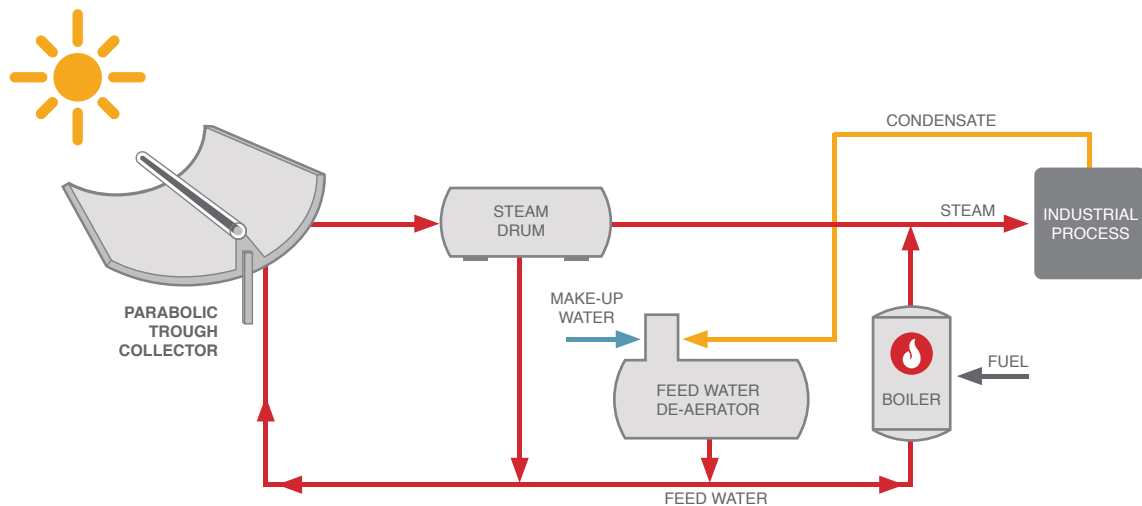


Example of solar thermal integration for preheating

IRENA [8]

### Direct steam generation

Water is partly evaporated in the concentrating collectors. The solar-heated steam is then separated from the remaining water in the steam drum before being supplied to the industrial process or the steam network of the factory. The treated condensate – also called feed water – is fed back to the collector field. Another option is **indirect steam generation**. In this case, the collector field heats water or thermal oil in a closed circuit to generate steam via a heat exchanger.

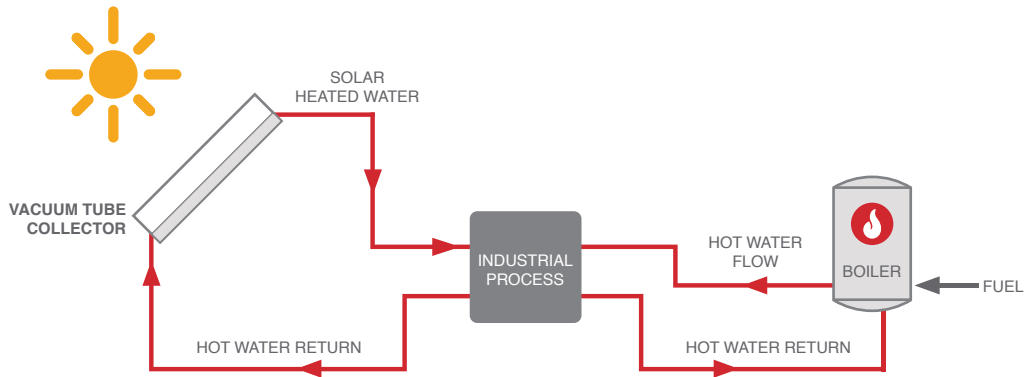


Example of solar heat integration to generate steam

IEA TASK 49 [9]

## Process heating

The solar field provides heat at a certain temperature to maintain the temperature of a bath or a thermal separation process. Additional heat is provided to the production process by a fossil fuel boiler. Both circuits are closed so that the cooled off water returns to the collector field or the boiler respectively.



Example of a solar system which supplies heat directly to an industrial process

IRENA [8]

## CHALLENGES

Integrating solar heat systems into industrial processes requires customised SHIP designs based on which production methods a company employs, which conventional heating system it has installed and which fuel is used. What do experts believe are the major barriers to successful integration?



“Despite there being a wide variety of low-temperature industrial processes, heat supply in industry often relies on steam boilers and steam distribution networks. The integration of solar process heat is a challenge in that it either acts directly on the processes, an approach that the industry is reluctant to implement, or on the heat supply system at the boiler preheating or steam network stage, which means higher pressures and temperatures than those required for the processes.”

**Dr Pedro Horta**

Head of Group Solar Process Heat and Industrial Systems, Fraunhofer Institute for Solar Energy Systems ISE, Germany



“After having analysed many different production processes, I concluded that opportunities for solar integration heavily depend on the conventional heating equipment being used. A tunnel pasteuriser, which gets its heat from an external heat exchanger, is a suitable match for industrial solar heat, whereas commonly used flash pasteurisation is difficult to incorporate as an external solar heat source.”

**Dr Bastian Schmitt**

Head of the Process Heat group at the Institute of Thermal Engineering (ITE) at University of Kassel, Germany



“Decision makers in manufacturing are sceptical. Production is their lifeblood. They are extremely reluctant to risk having a faulty or problematic system cause operational downtime.”

**Doran Schoeman**

Group Director of E3 Energy, South Africa



“SHIP is not just about switching from fossil fuels to renewables, but you will also have to identify waste heat potential if you want to achieve mostly shorter payback periods. Efficiency improvements could help many production businesses.”

**Christian Holter**

Managing Director of S.O.L.I.D., Austria

# SHIP SUPPLIERS

## EXPERIENCED AND “MARKET-READY” SUPPLIERS OF TURNKEY SHIP PLANTS SHOWN ON THE WORLD MAP OF SOLAR PROCESS HEAT SPECIALISTS 2017

### AUSTRALIA

NEP Solar: [www.nep-solar.com](http://www.nep-solar.com)

### AUSTRIA

Ecotherm Austria: [www.ecotherm.com](http://www.ecotherm.com)  
Feichtinger: [www.feichtinger-gmbh.at](http://www.feichtinger-gmbh.at)  
Fresnex: [www.fresnex.com](http://www.fresnex.com)  
Gasokol: [www.gasokol.at](http://www.gasokol.at)  
S.O.L.I.D.: [www.solid.at](http://www.solid.at)

### BRAZIL

Bosch/Heliotek: [www.bosch.com.br/termotecnologia](http://www.bosch.com.br/termotecnologia)  
Enalter Engenharia Indústria e Comércio: [www.enalter.com.br](http://www.enalter.com.br)  
Imax Energia: [www.imaxenergia.com.br](http://www.imaxenergia.com.br)  
Konus Icesa: [www.konus.com.br](http://www.konus.com.br)  
Sunshine Engenharia: [www.sunshineengenharia.com.br](http://www.sunshineengenharia.com.br)

### CANADA

Rackam: [www.rackam.com](http://www.rackam.com)

### CHILE

Pampa Elvira Solar: [www.ellaima.cl](http://www.ellaima.cl)  
Reinstein: [www.reinstein-energy.com](http://www.reinstein-energy.com)

### CHINA

Shandong Linuo Paradigma: [www.linuo-paradigma.com](http://www.linuo-paradigma.com)  
Beijing Sunda Solar Energy Technology: [www.sundasolar.com](http://www.sundasolar.com)  
Himin Solar: [www.himinsun.com](http://www.himinsun.com)  
Sunrain Solar Energy (Micoe): [www.en.sunrain.com](http://www.en.sunrain.com)  
Vicot Solar Technology: [www.vicot.com.cn](http://www.vicot.com.cn)

### DENMARK

Aalborg CSP: [www.aalborgcsp.com](http://www.aalborgcsp.com)

### FRANCE

Helioclim: [www.helioclim.fr](http://www.helioclim.fr)  
newHeat: [www.newheat.fr](http://www.newheat.fr)  
Suncnim: [www.suncnim.com](http://www.suncnim.com)  
Sunti: [www.sunti.fr](http://www.sunti.fr)

### GERMANY

Aschoff Solar: [www.aschoff-solar.com](http://www.aschoff-solar.com)  
CitriSolar Energie- u. Umwelttechnik: [www.citrinsolar.de](http://www.citrinsolar.de)  
Consolar: [www.consolar.de](http://www.consolar.de)  
Enersolve: [www.enersolve.de](http://www.enersolve.de)  
Industrial Solar: [www.industrial-solar.de](http://www.industrial-solar.de)  
KBB Kollektorbau: [www.kbb-solar.com](http://www.kbb-solar.com)  
Phönix Sonnenwärme: [www.sonnenwaermeag.de](http://www.sonnenwaermeag.de)  
Protarget: [www.protarget-ag.com](http://www.protarget-ag.com)  
Ratioplan: <http://ratioplan.bayern>  
Ritter XL Solar: [www.ritter-xl-solar.com](http://www.ritter-xl-solar.com)  
Solarlite CSP Technology: [www.solarlite.de](http://www.solarlite.de)  
Soliterm Group: [www.solitermgroup.com](http://www.solitermgroup.com)  
SunOyster Systems: [www.sunoyster.com](http://www.sunoyster.com)  
Sunset Energietechnik: [www.sunset-solar.de](http://www.sunset-solar.de)

### GREECE

Sole: [www.eurostar-solar.com](http://www.eurostar-solar.com)

### INDIA

ATE Enterprises: [www.ategroup.com](http://www.ategroup.com)  
Akson's Solar Equipment: [www.aksonsolar.com](http://www.aksonsolar.com)  
Aspiration Energy: [www.aspirationenergy.com](http://www.aspirationenergy.com)  
Inter Solar Systems: [www.intersolarsystems.com](http://www.intersolarsystems.com)  
Megawatt Solutions: [www.megawattsolutions.in](http://www.megawattsolutions.in)  
Oorja Energy Eng`g Services: [www.oorja.in](http://www.oorja.in)

Quadsun Solar: [www.quadsunsolar.com](http://www.quadsunsolar.com)  
Taylormade Solar Solutions: [www.tss-india.com](http://www.tss-india.com)

### ISRAEL

Tigi: [www.tigisolar.com](http://www.tigisolar.com)

### ITALY

Soltigua: [www.soltigua.com](http://www.soltigua.com)  
Trivelli Energia: [www.trivellienergia.com](http://www.trivellienergia.com)

### JORDAN

Millennium Energy Industries: [www.meisolar.com](http://www.meisolar.com)

### MEXICO

Agbel Ingenieria y Servicios: [agbelsadecv@gmail.com](mailto:agbelsadecv@gmail.com)  
Ausgreen Energia: [ausbertov@ausgreenenergia.com.mx](mailto:ausbertov@ausgreenenergia.com.mx)  
Calentadores Solares Bicentenario (Solarqro): [www.solarqro.com](http://www.solarqro.com)  
Energias Saubere: [www.ecosystems.com.mx](http://www.ecosystems.com.mx)  
Inventive Power: [www.inventivepower.com.mx](http://www.inventivepower.com.mx)  
Investti: [www.investtienergy.com](http://www.investtienergy.com)  
Modulo Solar: [www.modulosolar.com.mx](http://www.modulosolar.com.mx)  
SEA Sistemas de Ecotecnia Ambientales: [www.seaacotecnia.com](http://www.seaacotecnia.com)

### PAKISTAN

Krypton Energy: [www.kryptonenergy.com.pk](http://www.kryptonenergy.com.pk)

### SOUTH AFRICA

Energyweb: [www.energyweb.co.za](http://www.energyweb.co.za)  
Greenability Installations: [www.greenability.co.za](http://www.greenability.co.za)  
E3 Energy: [www.e3energygroup.com](http://www.e3energygroup.com)  
Holms and Friends: [www.holmsandfriends.co.za](http://www.holmsandfriends.co.za)  
Reach Renewable: [www.reach-renewable.com](http://www.reach-renewable.com)  
Solarzone: [www.solarzone.co.za](http://www.solarzone.co.za)

### SPAIN

Inersur: [www.inersur.com](http://www.inersur.com)

### SWEDEN

Absolicon Solar Collector: [www.absolicon.com](http://www.absolicon.com)

### SWITZERLAND

TVP Solar: [www.tvpsolar.com](http://www.tvpsolar.com)

### TURKEY

Anitcam Sunstrip: [www.sunstrip.com.tr](http://www.sunstrip.com.tr)

### USA

Artic Solar: [www.articsolar.com](http://www.articsolar.com)  
Chromasun: [www.chromasun.com](http://www.chromasun.com)  
Skyfuel: [www.skyfuel.com](http://www.skyfuel.com)  
Solargenix: [www.solargenix.com](http://www.solargenix.com)

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Solar associations and partner institutes in the Solar Payback countries can provide additional solar thermal suppliers and manufacturers:

**BRAZIL:** Abrasol, [www.abrasol.org.br](http://www.abrasol.org.br)  
**GERMANY:** BSW-Solar, [www.solarwirtschaft.de](http://www.solarwirtschaft.de)  
**INDIA:** STFI, [www.stfi.org.in](http://www.stfi.org.in)  
**MEXICO:** ANES, [www.anes.org](http://www.anes.org)  
**SOUTH AFRICA:** SANEDI, [www.sanedi.org.za](http://www.sanedi.org.za)

# SERVICES

## FURTHER SOURCES OF INFORMATION

### ► IEA SHC – Task 49

Solar Heat Integration of Industrial Processes  
<http://task49.iea-shc.org>

### ► SHIP Database

Database of Solar Heat Applications in Industrial Processes  
<http://ship-plants.info>

## GLOSSARY

- **Exajoule** is a unit denoting large amounts of energy at regional or global level. The exa-prefix means that an amount is multiplied by a number which starts with a one followed by 18 zeros ( $10^{18}$  = quintillion). 1 EJ is roughly equal to 278 TWh (terawatt-hours).
- **Final Energy Consumption** is the energy amount delivered as fuel or electricity to anyone but the energy sector itself, meaning either a household or an organisation, such as a hospital or a manufacturing business. Losses from conversion, transport and distribution do not factor into the calculation.
- **SHIP** stands for Solar Heat for Industrial Processes and is used in this brochure as the standard acronym for technologies or plants which deliver solar heat to industrial facilities. Other publications use different abbreviations or names to describe this type of application: Solar Process Heat (Task 49 of the IEA Solar Heating and Cooling Programme); CST or Concentrating Solar Thermal (Ministry of New and Renewable Energy, India); SIPH or Solar Industrial Process Heat (National Renewable Energy Laboratory, NREL, USA).
- **Solar fraction** or solar saving fraction is the amount of energy provided by the solar technology divided by the total energy required.
- **ESCO** is short for Energy Service Company and describes a business model in which the supplier offers its customers a heat supply contract instead of a turnkey system solution. ESCOs finance, operate and maintain SHIP systems while customers pay them either instalments based on the energy costs saved or fixed rates based on the energy amount delivered. In European directives, this model is termed EPC or Energy Performance Contracting. In US publications, it is called a third-party energy services agreement.
- **Survey among SHIP specialists.** In October/November 2016 solrico carried out a worldwide survey among turnkey suppliers of SHIP plants. The questionnaire defined turnkey as a system planned, supplied and installed by the seller. Of the approximately 130 companies contacted, 71 provided data and filled in a 4-page questionnaire. All 71 companies are shown on the world map (page 10/11).
- **Collector area** is one way to describe the size of a SHIP system. In the context of flat plate and vacuum tube collectors, the reference approach is based on **collector gross area**, the maximum projected area of the complete collector. In the case of concentrating collectors, the aperture area is used to describe the size of the collector field. It is defined as the projected area of the reflectors/mirrors. With parabolic trough and concentrating dish collectors, the supplier refers to the flat, rectangular area specified by the outer perimeter of the mirrors (aperture). To arrive at a collector area for linear Fresnel technology, the usual method is to add together the flat area of all primary mirrors. In the case of solar tower plants, it is the total area of all heliostats (mirrors). These collector area definitions have been used on the world map and to calculate the total collector area of the reference cases on page 3.
- **Solar thermal capacity** is derived from the collector area by using a conversion factor of  $0.7 \text{ kW}_{\text{th}}/\text{m}^2$ . The IEA SHC Programme agreed with trade associations on this factor to allow for the comparison of solar thermal collectors with other energy technologies. The factor is used in the case studies on pages 4 to 7. The actual output of a square meter may vary based on local solar radiation and the temperature level required for the process. You can find a definition of the "reasonable" collector output in reference 7, page 7.
- **Stagnation** describes the condition in which a collector reaches the maximum temperature, because there is no demand for energy, the pump is switched off and collector losses are equal to the radiation absorbed by the system. To prevent technical failures, all solar loop components must be resistant to high temperatures and pressure loads during stagnation. Suitable measures for stagnation management are a good emptying behaviour of the collector field, a well-designed expansion vessel, a drainback concept (water from collector loop is drained into the tank during zero-demand periods) and the defocusing of concentrating collectors [see reference 10].

# ABOUT SOLAR PAYBACK

## OBJECTIVE

Promoting the use of Solar Heat for Industrial Processes (SHIP) across the four partner countries by raising awareness of its technical and economic potential, and increasing willingness to invest in it.

## COUNTRIES

### Brazil



[www.abrasol.org.br](http://www.abrasol.org.br)



[www.ahkbusiness.de](http://www.ahkbusiness.de)

### Mexico



[www.anes.org](http://www.anes.org)



[www.mexiko.ahk.de](http://www.mexiko.ahk.de)

### India



[www.stfi.org.in](http://www.stfi.org.in)



[www.indien.ahk.de](http://www.indien.ahk.de)

### South Africa



[www.sanedi.org.za](http://www.sanedi.org.za)



[www.suedafrika.ahk.de](http://www.suedafrika.ahk.de)

## DURATION

October 2016  
to September 2019

## BUDGET

Total funds available for all  
four countries: EUR 2,958,920

## ACTIVITIES



Drafting a National Solar Process Heat Potential Study



Developing policy recommendations for the uptake of SHIP technologies at national level



Organising train-the-trainer workshops on planning and designing SHIP plants



Offering bankers and investors training on how to finance SHIP systems



Organising a local industry and stakeholder conference



Implementing an online matchmaking network for investors and technology providers



Developing a funding and business tool for planners and investors to create preliminary analyses of SHIP plants



Identifying reference cases in manufacturing to conduct three pre-studies, plus detailed monitoring of one site to facilitate the set-up of a demonstration system (in South Africa, Mexico and Brazil)



Identifying reference cases among existing SHIP plants to carry out detailed monitoring of one system (in India)





## COORDINATOR



[www.solarwirtschaft.de](http://www.solarwirtschaft.de)

**German Solar Association**  
**BSW-Solar**  
Mrs Wibke Korf  
[korf@bsw-solar.de](mailto:korf@bsw-solar.de)  
Phone: +49 (0)30 297 778 813

## GERMAN IMPLEMENTING PARTNERS



[www.ise.fraunhofer.de](http://www.ise.fraunhofer.de)



[www.deginvest.de](http://www.deginvest.de)



[www.solrico.com](http://www.solrico.com)

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## REFERENCES

- [1] International Energy Agency (IEA), World Energy Statistics 2016, online tables  
[www.iea.org/statistics/](http://www.iea.org/statistics/)
- [2] International Renewable Energy Agency (IRENA), calculations by Deger Saygin based on IEA source [1]
- [3] IRENA, Renewable Energy Options for the Industry Sector, Global and Regional Potential until 2030, 2015  
[www.irena.org](http://www.irena.org)
- [4] European Solar Thermal Industry Federation (ESTIF), Solar Heat for Industrial Process Heat – a Factsheet  
[www.estif.org](http://www.estif.org)
- [5] AEE INTEC, Database of Realised SHIP Plants  
[www.ship-plants.info](http://www.ship-plants.info)
- [6] IEA TASK 49, Process Heat Collectors: State of the Art and Available Medium Temperature Collectors, December 2015  
[www.task49.iea-shc.org](http://www.task49.iea-shc.org)
- [7] IEA TASK 49, General Requirements and Relevant Parameters for Process Heat Collectors and Specific Collector Loop Components, November 2012  
[www.task49.iea-shc.org](http://www.task49.iea-shc.org)
- [8] IRENA, Solar Heat for Industrial Processes, Technology Brief E21, January 2015  
[www.irena.org](http://www.irena.org)
- [9] IEA TASK 49, Integration Guidelines, February 2015  
[www.task49.iea-shc.org](http://www.task49.iea-shc.org)
- [10] IEA TASK 49, Overheating Prevention and Stagnation Handling in Solar Process Heat Applications, January 2015  
[www.task49.iea-shc.org](http://www.task49.iea-shc.org)
- [11] REN21, Renewables 2016. Global Status Report, June 2016  
[www.ren21.net](http://www.ren21.net)

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SUSTAINABILITY

INTEGRATION

OPTIMISATION

"This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety supports this initiative on the basis of a decision adopted by the German Bundestag."

Supported by:



Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

**SOLAR  
HEAT  
FOR  
INDUSTRY**



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